North Korea bargains with nuclear diplomacy

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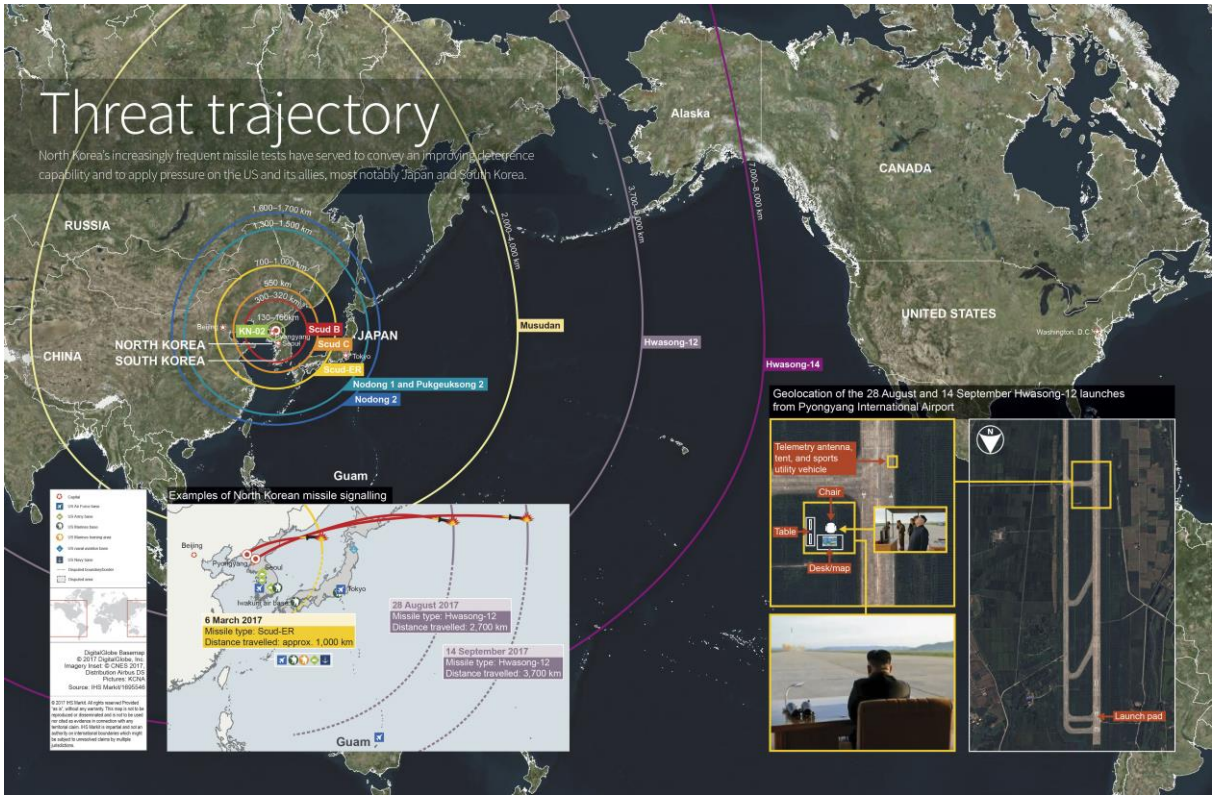
The pace and rhetoric of North Korea's nuclear and missile programmes have shifted the uneasy status quo of security in Northeast Asia. *Karl Dewey and Alison Evans* examine Pyongyang's strategy amid rising regional tensions. *Robert Kelley* and *Markus Schiller* examine North Korea's 'H-bomb' claims

On 22 September, North Korean Minister of Foreign Affairs Ri Yong-ho further heightened international concerns over his country's nuclear programme, suggesting that North Korea could conduct "the most powerful detonation of an H-bomb" over the Pacific Ocean. The statement came less than three weeks after North Korea had conducted its sixth confirmed nuclear test, which it claimed was an 'H-bomb'.

Although the configuration of the device detonated on 3 September remains to be confirmed, an atmospheric test of any nuclear device would be considered highly provocative by Washington and its allies. Ri noted, however, that this was only an option, and that any decision would ultimately be made by North Korea's Supreme Leader, Kim Jong-un.



Map showing assessed ranges of North Korean ballistic missiles. (©2017 IHS Markit)

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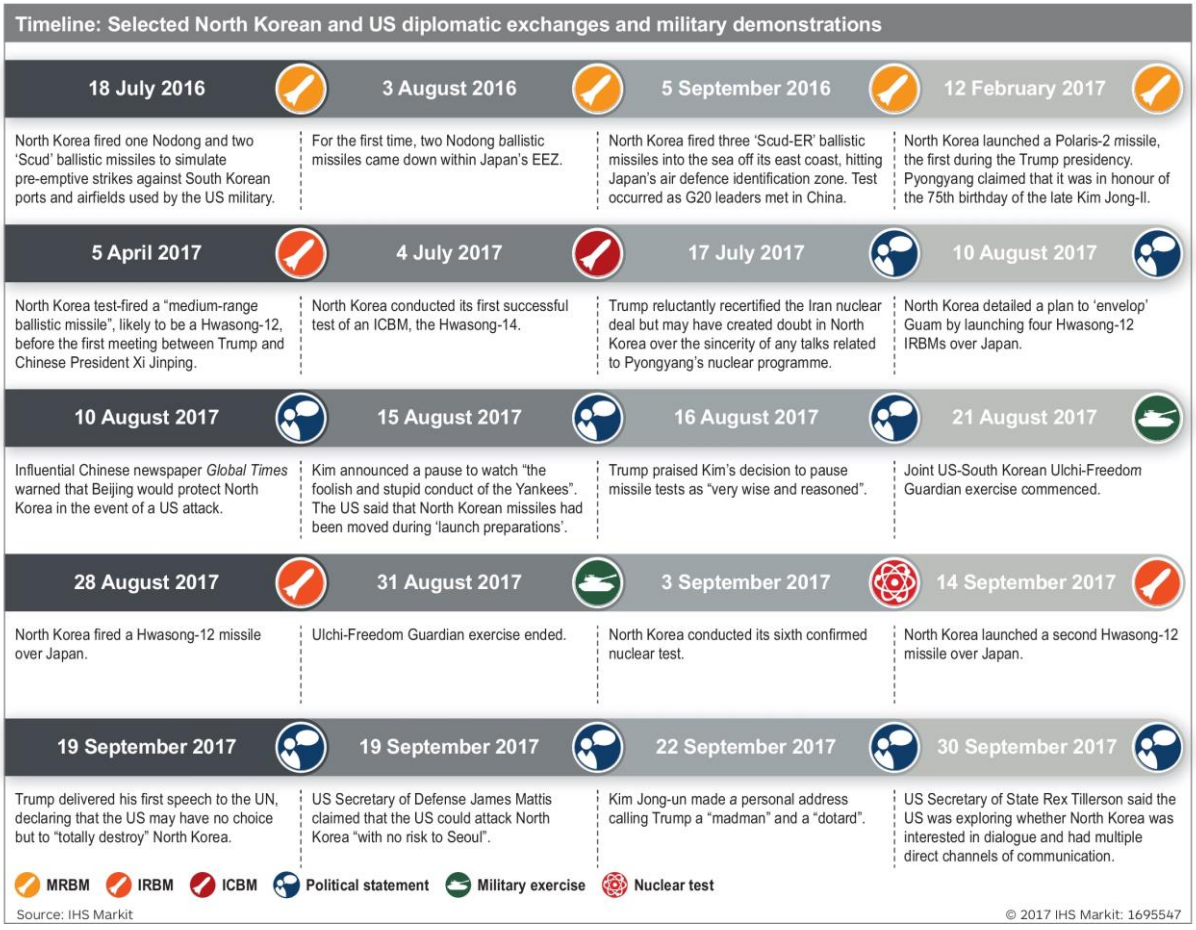
Building pressure

This increase in the perceived threat and a necessity for military readiness on both sides can be traced back to 2013, when Pyongyang began to significantly increase the scale, tempo, and scope

of its ballistic missile (BM) programmes. In addition to overseeing more missile launches during the past five years than North Korea's two previous leaders since the end of the Korean War in 1953, Kim has continued the development of new solid- and liquid-fuelled engines, enhanced air- and sea-defence capabilities, and added a naval leg to North Korea's deterrence strategy. Similar observations regarding frequency and diversity apply to the nuclear programme: Kim has overseen four of the confirmed six tests, including two purported H-bombs.

Nonetheless, nuclear deterrence requires more than just nuclear-tipped missiles. It also requires effective communication and the credibility of intent, which is itself underpinned by a force's ability to both conduct and survive a nuclear strike. At present, North Korea's nuclear deterrence faces numerous challenges in each of these elements. However, the conventional artillery and presumed chemical weapons (CW) capability along the de-militarised zone (DMZ) that separates North and South Korea have served to deter attacks, including a planned strike by the US on the Yongbyon nuclear complex in 1994.



Timeline of selected North Korean and US diplomatic exchanges and military demonstrations (©2017 IHS Markit)

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Deterrence by punishment relies on the threat of inflicting pain on an adversary to prevent aggression, but North Korea cannot yet satisfactorily reach the US – the linchpin of Japanese and South Korean security. Although it is working towards hitting key US targets such as Washington, DC, to date Pyongyang's intercontinental ballistic missile (ICBM) programme has been experimental and lacking in credibility, although this is likely to change.

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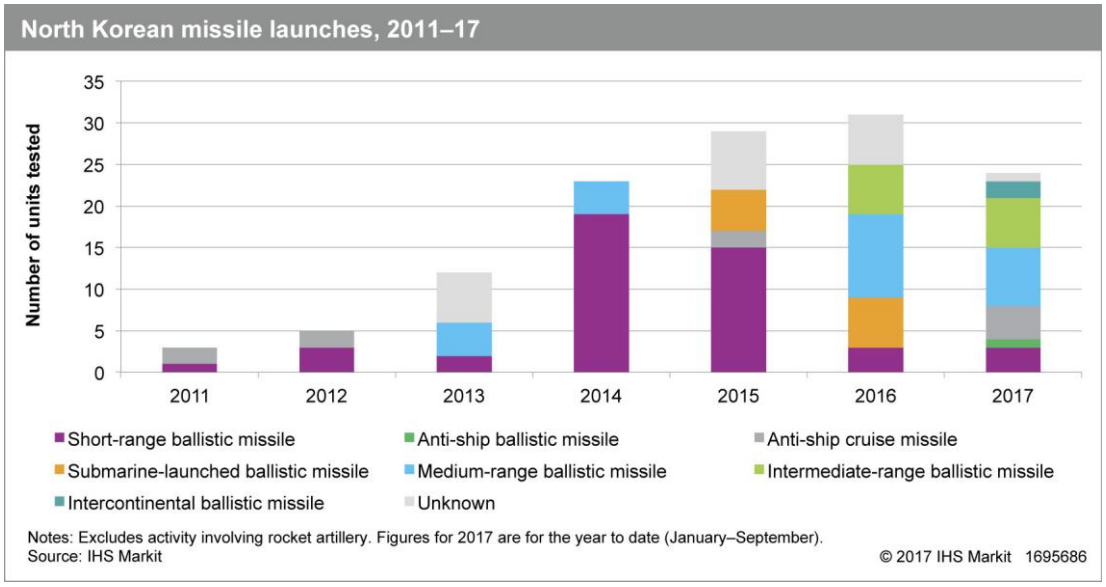
Negotiating strategies

In addition to its deterrence aspirations, North Korea has historically used its nuclear programme to gain diplomatic and economic benefits. For example, the first North Korean nuclear crisis in 1993–94 was triggered after Pyongyang signalled its intention to withdraw from the Nuclear Non-Proliferation Treaty (NPT) on 9 March 1993. This ultimately resulted in bilateral talks with the US and the eventual signing of the 1994 Agreed Framework.

During this 18-month period, North Korea conducted a sophisticated diplomatic-military campaign, with various military actions timed to support the diplomatic effort. These included the deployment of large numbers of artillery pieces and multiple rocket launchers near the DMZ, and an apparent strengthening of its CW capability in the run-up to talks. North Korea also placed its armed forces on alert, and conducted what was then the largest-ever 'Scud' display on 29–30 May 1993, featuring three short-range Scud-type missiles, and a longer-range Nodong.

This series of events shows how North Korea's military forms an integral part of its diplomatic toolkit. Far from being irrational, testimony from a former North Korean diplomat – cited by Narushige Michishita in the *Journal of Strategic Studies* in 2003 – suggests that considerable preparation was undertaken for the first crisis. The preparation included the assembly of a special 'Permanent Nuclear Team' (haek sangmu jo) "sometime around 1991", bringing together approximately 20 officials from the Korean Workers' Party (KWP), the Ministry of Atomic Energy Industry, the Ministry of Foreign Affairs, the Ministry of the People's Armed Forces, and other security agencies.



North Korean missile launches, 2011–17 (©2017 IHS Markit)

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The Agreed Framework signed in October 1994 was highly successful for North Korea. In exchange for Pyongyang freezing its nuclear programme, it gained two new Light Water Reactors (LWRs) and a US agreement to supply oil pending their construction. North Korea also gained a new international prominence, and the US-South Korea 'Team Spirit' joint military exercises were cancelled during the 1994–96 negotiating period.

Pyongyang's institutionalised strategising can be seen in other provocations. For example, in 2010 it sank the ROKS *Cheonan* in March and shelled Yeonpyeong Island in November. Despite

occurring months apart, defector testimony related by the former high-level counter-intelligence officer Jang Jin-Sung in his book *Dear Leader* (May 2011) suggested that these actions were connected.

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Diplomacy revisited

Given this pattern of considered behaviour, North Korea's current escalation is also likely to be part of a sophisticated wider 'win-win' strategy. In the short term, each new test helps to fulfil a particular operational need and signals the increasing credibility of its deterrence. In the longer term, the increasing scale and frequency of North Korea's nuclear and missile programmes crowd out individual signals and contribute towards growing pressure on the US and its Northeast Asian allies.

North Korea will probably be prepared to maintain its accelerated pace of missile launches and tests in the coming months, with the hope of focusing any future negotiations – including informal ones aimed at de-escalating the current crisis – on the frequency of such actions rather than the components of its nuclear or missile programmes.

Premised on the assumption that there are no credible military options available to the US in retaliation for demonstrations of North Korea's weapons, it is likely that North Korea is seeking to improve its position in any future negotiations and to force concessions from the US. Short-term objectives are likely to include the lifting of preconditions for talks and the cessation of future joint US-South Korea military exercises.

In the long term, Kim's 'byungjin roson' policy (which envisages a programme of economic growth in parallel with nuclear development) suggests that North Korea will seek foreign aid and/or the lifting of sanctions to foster greater economic prosperity. However, these aims remain subordinate to its national security.

Given increasing sanctions, recent tests seem at odds with the economic imperatives of the parallel development policy, yet the North Koreans have expressed a desire to talk with the US as long as the conditions are right. Given the necessity for the current government to save face externally and to remain unchallenged domestically, North Korea's leadership likely views sanctions as a short-term cost to the long-term aim of forcing negotiations on more favourable terms.

This North Korean game plan was visible in 2017 in Pyongyang's sequencing of the most provocative actions coinciding with the run-up to the annual joint US-South Korea Ulchi-Freedom Guardian (UFG) exercise during 21–31 August. These included launches of Hwasong-12 (KN-17) and Hwasong-14 (KN-20) missiles before UFG, and the sixth nuclear test on 3 September.

North Korea first successfully tested its single-stage Hwasong-12 intermediate-range ballistic missile (IRBM) on 14 May, and its two-stage Hwasong-14 ICBM on 4 July. Although these tests were conducted on lofted trajectories to shorten the distances travelled, they were particularly alarming due to the new engine type and the increased potential range, placing part of the US mainland – Alaska – at risk for the first time.

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Missed messages?

Such events point to continuity in North Korea's strategies of provocation and de-escalation. Importantly, provocations are presented as plans that require leadership approval, such as those by Foreign Minister Ri and Gen Kim. Outside their direct effects of heightening international concerns, this practice presents Kim Jong-un as open to negotiations, albeit on his terms. It also enables North Korea to present such provocations as a response to foreign aggression, and to measure the extent of any 'compromise' in future actions.

Furthermore, conditioning provocations on US actions strongly suggests that the North Korean government and military manage their signals and have considered escalation and de-escalation scenarios. If this interpretation is correct, it suggests that Kim Jong-un's decision to pause the plan to fire missiles near Guam was an invitation for the US to reciprocate de-escalation.

Kim Jong-un examining an alleged thermonuclear device. (©2017 IHS Markit)

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Given the timing, the most tangible concession would have been the US suspending the UFG exercise. Although any cancellation could be seen as rewarding bad behaviour, North Korea cites the 1994–1996 suspension of the exercises as a previous demonstration of goodwill. The timing also suggests that the nuclear test after UFG should be seen as a punishment for the US failing to act on the offer.

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Multiple audiences

North Korea's attempts to use military actions to signal to the US its desire for de-escalation or its readiness to take military action are inherently risky. In addition to requiring a balance between showing caution and resolve, there are few guarantees that such signals will be interpreted as intended, particularly given Trump's perceived unpredictability and his characterisation of Kim as an irrational and suicidal actor, or US Secretary of Defense James Mattis's belief that North Korea cannot be deterred.

Significantly, provocations also affect other countries in the region, increasing the potential for miscalculation and unintended outcomes. This risk is particularly true if the long-held assumption

that the US lacks credible military options is disintegrating. Although no plans have been publicly released, Mattis hinted on 19 September that the US was considering military options against North Korea that would not leave Seoul at risk of devastating retaliatory strikes. Such options, if credible, would be particularly escalatory because North Korea has clearly stated that an attack on it constitutes a scenario in which it would be prepared to use nuclear weapons.

Pyongyang has also indicated that other US actions – including the deployment of additional US troops in Japan and South Korea – would cause it to consider pre-emptive strikes. Although such deployments may reassure US allies, North Korea has repeatedly stated that it regards US bases as forward staging posts for an invasion.

Although North Korean threats to attack the US in response to changes in its military posture in the region currently lack credibility, Washington faces an incentive to act in the ever-closing window before North Korea has the operational missile capability to reach the US mainland and to impede its freedom of action. In the interim, North Korea is highly likely to attempt to maintain pressure on the US and to continue the increased frequency and intensity of its provocations, including threatening the use of nuclear weapons.

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Dual freezes

Although the US has been reluctant to engage with North Korea, other actors have tabled a number of diplomatic solutions including the idea of a 'dual freeze'. This would see the US temporarily halting its joint military exercises in exchange for North Korea ceasing its nuclear activities. Although this solution neatly addresses concerns on both sides, multiple statements and images released by North Korea underline its commitment to retaining its nuclear deterrence, even if it were to agree to suspend testing.

On 30 August 2017, North Korea's Korean Central News Agency released photos of the 29 August launch of a Hwasong-12 intermediate-range ballistic missile lifting off from the launch pad at an undisclosed location near Pyongyang. (STR/AFP/Getty Images)

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North Korea's nuclear programme is too closely tied to its sovereignty and the regime's survival to be surrendered without considerable costs to Pyongyang's domestic audiences. Even if North Korea retained its nuclear weapons and an agreement focused solely on stopping further production, the programme's size, scale, and secrecy have led to uncertainty over the extent of its progress. For any talks to ensure that North Korea has stopped its activities, North Korea would have to accept on-site inspections at declared and hitherto undeclared sites. Furthermore, should North Korea have developed boosted or thermonuclear weapons, the decay of tritium over time

means that any stoppage within its nuclear infrastructure would impact the credibility of its weapons stock.

In addition to these domestic concerns, North Korea is likely to have increasing concerns about the credibility of the US as a negotiating partner, particularly given Trump's attitude towards the Joint Comprehensive Plan of Action (JCPOA) signed between Iran and the UN Security Council's five permanent members plus Germany: P5 +1 (China, France, Germany, Russia, the United Kingdom, and the US) in July 2015. Although this was regarded as a significant step in preventing Iran from getting nuclear weapons by the previous administration of Barack Obama, in October 2017 Trump refused to certify that the JCPOA met the broader criterion of being of 'vital US national interest', despite the International Atomic Energy Agency (IAEA) and other observers confirming that Iran was in compliance with its safeguards agreement. For Pyongyang, such inconsistency is likely to raise doubts about the sincerity or longevity of any talks with the US.

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Assessment of fission primary

To date, there have been three sets of visual clues to the configuration of North Korea's "H-bomb " and its intended weaponisation. These include images of Kim's inspection of a reported thermonuclear device at the country's Nuclear Weapons Institute; a schematic of an ICBM re-entry vehicle (RV) in the same visit; and images from a government-sponsored reception honouring North Korea's nuclear scientists.

Although these images have been released as propaganda, one audience includes external analysts sceptical about North Korea's thermonuclear claims. *Jane's* has examined the key images for consistency and the information that can be gleaned. Most analysis concerns the fission primary, because there are many signatures; there are no signatures of how the secondary is designed, so its properties can only be assumed.

Following the 3 September nuclear test, North Korea released images of Kim watching an H-bomb being loaded into the RV of a new ICBM. A live demonstration is very unlikely and the device on display is almost certainly a model that includes many features of a workable device. One indication of this is that it is made for easy disassembly and economical machining. This can be ascertained as the welds, cable connections, and penetrations do not appear to be rugged enough to handle the stresses and vibrations of ICBM flight.

Furthermore, the cables and connectors for wires entering the metal shell are poorly supported and routed across sharp corners that would probably cause damage. For an intended weapon, this is impossibly poor design practice; it is also at odds with a better model displayed in March 2016.

Given the need to convince external audiences, the model's casing likely represents the external configuration of a nuclear device, and appears to be machined aluminium. There are flanges (supports and disassembly parting lines) at each point in the model where the contour changes from spherical to a straight taper. These flanges appear to be spot-welded to the body, which is completely inadequate for the rigours of flight.

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Assessment of poster visible behind VIP delegation

A poster of a device similar to the model is visible behind the VIP delegation examining the thermonuclear bomb model. The poster provides a credible image of how a real thermonuclear device would fit into a displayed RV.

The poster is visible above the device being examined by Kim Jong-un, on the top left. (KCNA)
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Jane's has scaled the diameters and lengths in the poster image to similar items in the model being examined by Kim. There is consistency in the measurements, for example the diameter of the Arming, Firing and Fusing (AF&F) set. The measurements were then used to estimate masses of the explosive package.

The weight of the dumb-bell-shaped object is concentrated at the two centroids of the spherical sections: the primary at the aft-end and the smaller secondary. Masses of the nuclear stages were used to estimate the static margin, which is the ratio of the centre of pressure and centre of mass. Included in the estimate was the mass of the radiation case, which is large and significant compared with the exploding spheres.

Static margin provides a figure of merit for whether a vehicle flying through the air will fly in a stable manner or will tumble if the mass is too far aft. The mass distribution with respect to the nose tip is the critical value. *Jane's* estimates the smaller forward sphere at 30–50 kg; the large sphere is easier to model at about 145 to 170 kg; the heavy uranium case is modelled along the axis of the vehicle and weighs about 80 to 140 kg.

Therefore, the explosive payload is estimated to be between 255 kg and 360 kg. The uncertainties associated with these estimates are very high given that they are derived from unscaled drawings. The nuclear design is also unknown; it is even unknown whether plutonium or uranium is the primary fuel. Nevertheless, the mass is probably well within these ranges.

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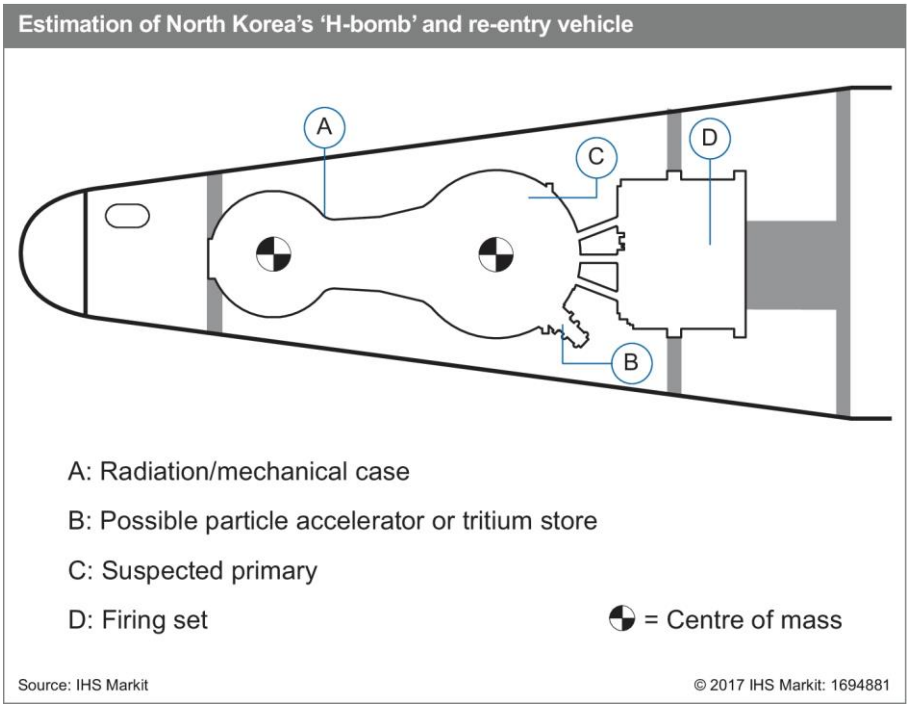
Jane's has modelled the RV and warhead in a schematic form for clarity (see below).



A schematic of North Korea's 'H-bomb' and re-entry vehicle. (©2017 IHS Markit)

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Assessment of technician joining two bomb sections

The technician is wearing significant protective clothing: white coveralls, a face mask, anti-contamination hat, and gloves. This is consistent with 'clean room' procedures and hazardous material protection. Because of the face mask, it is likely that this is hazard protection for the worker.

A very significant feature of the image is what is not visible. If this is a thermonuclear device being assembled, there would normally be a cylindrical container visible inside, coaxial with the outer case. Such a case would require a very strong leak-tight joint to contain the thermonuclear reactions. It would be very difficult to make such a joint once this mating operation is complete. This leads to the likelihood that the case that is being joined, is in fact, the actual nuclear container of the upper nuclear primary stage and the thermonuclear secondary at the bottom.

A technician joins two sections. (KCNA)

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The most likely material for the case being joined is natural uranium metal alloy. This would account for the slightly gold tone of the upper section, which is the colour of freshly machined uranium. Uranium is a very strong structural material and has a very high density, desirable in this application.

Alloys of uranium, such as 'Mulberry' U-7.5Nb-2.5Zr, can be described as stainless and would be suitable for storage periods of many months in air. The two sections can be smoothly joined by welding, or more commonly with mechanical solutions common in the aerospace industry – especially if there is a tongue and groove structure.

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Yield estimations

Despite the released images, there is little to link the displayed 2017 device with that tested. *Jane's* assesses that the large yield alone is an insufficient indication that the nuclear test of 3 September was a test of a true thermonuclear device. An underground test using only unboosted fission could easily produce a yield of the order of 150 kilotons.

If North Korea is intent on deception, it could design and fire such a device unseen and still claim it was a hydrogen bomb. Alternatively, if Pyongyang wished to remove ambiguity, it could vent a small amount of the gases and particulates produced by the detonation. Given that Pyongyang is willing to release high-quality images of a claimed device in an apparent effort to convince the international community, releasing a small amount of radiation would add considerably to its claims.

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Technical device analyses of 2016 and 2017 models

The suspected primary stage of the 2017 model's casing is similar in many respects to the 2016 device, which was assessed to be a model of a single-stage nuclear device that may, or may not, be boosted (see below). Although they may be made of different materials and have a large number of circular access ports of unknown value, they appear to be approximately the same size and useful to compare.

High-explosive detonation system

The 2016 device has a number of cables entering the environmental case. From several images, it is clear there are 12 cables entering the metal shell, via four cable ports, that are probably the detonator cables for 12 equally spaced detonation points on the high-explosive sphere that compresses fissile material.

Twelve identical polygons covering the surface of a sphere are known as a dodecahedron. This is less than classical firing systems with 32 points, but a way to enhance the number of points was published by the Institute of Science and International Security (ISIS) in November 2011. According to the ISIS report *Iran's Work and Foreign Assistance on a Multipoint Initiation System for a Nuclear Weapon,* "The IAEA also obtained from member states details of the design, development, and possible testing of what is called in IAEA information the R265 shock generator system, which is a round multipoint initiation system that would fit inside the payload chamber of the Shahab 3 missile [made by Iran and similar to the Nodong 1] tri-conic nose cone. This device involves a hemispherical aluminium shell ... channels are cut into the outer surface of the shell ... and contain explosive material. Each channel terminates in a cylindrical hole ... [that] contains an explosive pellet."

The report continued, "The geometrical pattern formed by channels and holes is arranged in quadrants on the outer hemispheric surface which allows a single central point of initiation and the

simultaneous detonation of explosives in all the holes on the hemisphere. This in turn allows the simultaneous initiation of all the high explosives under the shell by one exploding bridgewire (EBW). If properly prepared, the R265 constitutes the outer part of an explosively driven implosion system for a nuclear device.

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Arming, Firing, and Fuzing

Jane's assesses that the object next to the nuclear device in the 2016 image is a firing set consisting of components such as batteries, high-voltage transformers, and safing systems. It is a simple unit, without connections to the device. A poster of the 2016 device shows the firing set mounted forward of the nuclear device in the RV.

In 2017, a similar cylindrical object of approximately the same size is next to the device. It has several items bolted to its top and multiple cable connecters. In an accompanying poster, this firing set is mounted aft of the device when in the RV. A significant difference between the device model and the AF&F model is the quality of construction. Complete circumferential welds of good appearance connect two flanges on the AF&F to the body, unlike the crude welding visible on the device itself.

Boosting systems

Boosting is a means of enhancing fission yield in a single-stage nuclear device. Boosting is achieved by adding small amounts of the hydrogen isotopes tritium (T) and deuterium (D) to a fission bomb. When the fission device explodes, D and T fuse and produce copious quantities of very high energy neutrons that 'boost' the fission reaction. This can increase the yield by several factors.

Although the fusion of D and T is a thermonuclear reaction, boosting alone does not make the device a true thermonuclear bomb. These use the very fast neutrons to burn materials which do not usually fission, such as Uranium-238. As such, there is considerable ambiguity over North Korea's propaganda claims of an H-bomb: this could refer to a boosted weapon, a true thermonuclear weapon, or remain a bluff.

D and T for boosting may be stored outside the device and transferred inside just before explosion. They could also be conceivably stored inside the device in various forms. Both engineering solutions have advantages and disadvantages.

In the case of the 2017 device, there are no visible high-pressure gas lines suitable for tritium delivery going from the AF&F to the device, only electrical. However, for that reason it is likely that the fission stage depicted in this device is either unboosted or contains the tritium inside the device prior to launch. Internal storage can greatly complicate logistics and reliability.

Large penetration into the sphere

The 2016 device has a very large hole from the outside into the sphere. This is an unusual feature and is not adequately understood. The best explanation is that it is an observation port in a VIP model to enable Kim to see the interior. It might also be part of a safing system or entry-penetration for a boost system.

Kim Jong-un examining an alleged fission device in 2016.To the left is the assessed firing device. It has fewer details than a very similar cylindrical object connected to the 2017 thermonuclear device. (KCNA)

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In the 2017 model, this is replaced by a black object that appears to be pointed towards the centre of the sphere. Its purpose is again unknown. One theory is that it is a small nuclear particle accelerator to provide neutrons to start the chain reaction. This would account for the cable to the aft end that is not properly supported for flight stresses. It could also be a form of tritium storage for boosting.

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Re-entry vehicles

Regarding the RV, noteworthy observations can be made by looking closely at the three exhibits placed around the thermonuclear bomb model: the upright exhibit resembling a Hwasong-14 front part; the supposed RV that the physics package is to be mated with (laying sideways behind Kim); and the poster in the background.

Upon examination, the geometric shapes of the three do not really fit together. The model of the Hwasong-14 front part clearly has a bi-conic shape, with two different cone angles, whereas the object depicted at the poster has a conical shape with a single cone angle. The exact shape of the 're-entry vehicle' lying behind the H-bomb model is difficult to determine from the available photos, but it seems that this object also features just one cone angle, similar to the object depicted on the poster.

This would indicate that the object standing behind Kim is not the RV itself, but a shroud to protect the actual RV during launch, which also acts to hide anything mounted on the missile from external observation. The other object that seems to be mated with the H-bomb model therefore seems to be the actual RV, from the way it is depicted in the poster.

If this assumption is true, the RV should be small enough to fit inside the shroud. Therefore, the precise dimensions of the two objects need to be calculated. The precise dimensions of the Hwasong-14 are still subject to some debate, but measurements by *Jane's* indicate that the shroud, which – according to photos from the Hwasong-14 launches – has the same diameter as the Hwasong-14's upper stage, has a base diameter of around 140 cm, and a length of approximately 300 cm.

The dimensions of the 're-entry vehicle' can be derived from the poster, assuming that the drawings were made to scale. With the H-bomb's joint diameter measured as between 31 and 32

cm, the whole RV could have a length between 300 and 310 cm, and a base diameter of around 120 cm. Although there are dimensions written on the drawing, they are difficult to decipher due to the poor quality of the available photos. The base diameter is difficult to read, but the length could be read as 307 cm, which would be in line with the derived lengths.

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Missile range testing

Suggestions that a North Korean ICBM has been successfully developed are premature. The Hwasong-14 remains in development, and an essential element of a flight-test programme is full-range testing. If North Korea fires a long-range missile far over the horizon, it will have little or no way to judge performance in terms of range, accuracy, and survivability. It is even possible that Pyongyang is dependent on news stories based upon Western intelligence to judge the range that previous tests have attained.

In a mature flight-test programme, a range ship would be stationed in the intended target area. This ship would use radar and other instruments to detect the flight path and final splashdown point of the RV. Only North Korean planners would know the actual targeted point, but the positon of the range ship would give a strong indication of the goal. In addition, if North Korean scientists wanted to know if the heat shield and nuclear package had survived re-entry, there would likely be on-board telemetry measuring temperatures, vibrations, and flight health data. The range ship would collect this data when it had line-of-sight acquisition of the RV.

These techniques have been used in the flight-test programmes of states developing long-range missiles to develop and certify re-entry systems. Indeed, it is noteworthy that by treaty agreement, during the Cold War Strategic Arms Limitation Talks (SALT) during the 1970s the Soviet Union and the US agreed to not encrypt all telemetry data so that each side was receiving a portion of the other's flight-test data and analysing it. This formed part of the transparency efforts of that era.

A crude test for North Korea would be simply to detonate a high-explosive charge in the RV at the intended point of detonation. Detailed quantitative flight data would not be collected, but the success or otherwise of the flight could be determined in a binary fashion. Threats by North Korea to detonate an actual nuclear device over the Pacific are an extreme version of this scenario. Intelligence analysts would glean much from such an event: collection of large amounts of particulate debris could enable modelling of the North Korean device and its performance to a very high degree of certainty.

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On the web
China maintains contingencies for North Korean instability
North Korea ups pace of ballistic missile launches
North Korean nuclear programme advances

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